Weekly changes in phytoplankton species composition, diversity, abundance, and biomass across the Northern Levantine Basin shelf waters

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Abstract- A time series sampling program has been initiated by the Institute of Marine Sciences, METU, at three stations across the Turkish continental shelf in the northern Levantine basin to collect data on a number of biological, physical, and chemical oceanographic variables. The coastal ecosystem of the northern Levantine basin changes rapidly as it receives increasing anthropogenic load. The most predominant anthropogenic impact is the severe eutrophication experienced in Iskenderun and Mersin Bays. Eutrophication is considered to play a key role in the ecosystem by leading to substantial alterations in the structure and function of marine flora and fauna both qualitatively and quantitatively, which is the first target of the increased nutrient loads. Recent studies have shown alarming basinwide expansion of the eutrophication phenomenon. Compared to the Black Sea the region may be regarded as one of the least studied extreme environments. Significant changes in number and biomass of phytoplankters within short time intervals are observed at all stations throughout the year. A general view at the composition of phytoplankton for period June 1997-May 1998, reveals that diatoms' contribution in terms of biomass to the bulk is much higher than all the other groups at three stations during all seasons. Based on annual averages, diatoms made up almost 90% of the total phytoplankton biomass at the nearshore station. This figure was 84% for the mid-station and about 70% for the offshore station. Next to diatoms, dinoflagellates, coccolithophorids and small flagellates are the other important constituents of the phytoplankton in the region. Phytoplankton biomass levels showed a decreasing trend towards offshore at all seasons. Based on seasonal averages the minimum and maximum biomass values ranged in between 456 and 1039 mg/m^3 at the nearshore station, in between 50 and 918 mg/m^3 at the mid-station and in between 30 and 150 mg/m^3 at the offshore station. Multivariate analyses have shown formation of three distinct seasonal phytoplankton assemblages (winter and early spring, late spring - early summer and late summer – early autumn) throughout the year. Temperature rather than salinity displayed the major role in determining such clusters. Additionally, highly significant correlations have been observed between the ambient physico-chemical parameters and the phytoplankton biomass and abundance in the region.

Keywords- phytoplankton, diversity, abundance, biomass, northern Levantine basin.

Introduction

The coastal and the cyclonic areas of the Levantine basin differ from the open waters in their biology, chemistry and physics since cyclonic areas receive relatively high nutrients from the deep water compared to the open waters and the coastal waters are completely different ecosystems. Dramatic increase in human population, intense marine traffic, pollutants of industrial and domestic origin in addition to agricultural and atmospheric loads make the coastal ecosystems of the region extremely vulnerable to the imposed environmental burdens. In the northern Levantine basin (NLB), the most predominant anthropogenic impact is the severe eutrophication experienced in Iskenderun and Mersin Bays. Compared to the Black Sea the region may be regarded as one of the least studied extreme environments.

Material and Methods

Weekly cruises were held at three stations (Fig. 1) across the Turkish continental shelf in the northern Levantine Basin to collect time series data on a number of physical, chemical and biological oceanographic variables (for details see Uysal, 2000). Results discussed in this paper concern mainly the surface phytoplankton.

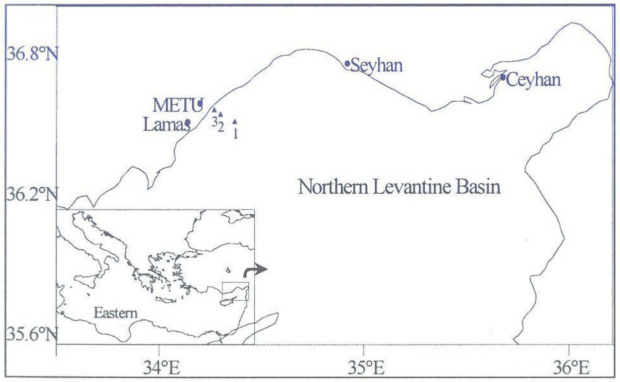

Fig. 1. Location of sampling stations in the northern Levantine basin.

Results

Phytoplankton biomass as well as abundance showed remarkable decrease towards offshore throughout the year. Based on seasonal averages the minimum and maximum biomass values ranged in between 456 and 1039 mg/m^3 at the nearshore station, in between 50 and 918 mg/m^3 at the mid-station and in between 30 and 150 mg/m^3 at the offshore station. A general look at the composition of phytoplankton for the period June 1997-May 1998, reveals that diatoms' contribution to total biomass was highest throughout the year in the shelf waters

(Fig. 2). Based on annual averages, diatoms made up about 90%, 84% and 70% of the total phytoplankton biomass at the nearshore, middle and offshore stations, respectively. Diatoms were overwhelmingly dominant (98%) at nearshore station during winter. Besides diatoms, dinoflagellates, coccolithophorids and small flagellates are the other important constituents of the phytoplankton in the region. Contribution of such groups to the total biomass are more pronounced towards offshore. Dinoflagellates (41%) and coccolithophorids (23%) have made relatively significant contribution to the total biomass at the offshore station during summer and winter, respectively.

Significant changes in phytoplankton biomass are observed at weekly intervals at all stations throughout the year (Fig.s 3 a,b,c). The minimum and maximum total phytoplankton biomasses varied between 9.5 and 6128 mg/m^3 at the nearshore station, in between 6.4 and 5607 mg/m^3 at the mid-station and in between 3.3 and 794 mg/m^3 at the offshore station. Similar trends are also true for the cell abundances. Total cell numbers varied between 1.08x10^4 and 5.63 x 10^6 cells/l at the nearshore station, in between 9.6x10^3 and 2.61 x 10^6 cells/l at the mid-station and in between 4.32 x 10^3 and 4.47 x 10^5 cells/l at the offshore station. The magnitude of week to week variations in abundances are much higher at nearshore station in comparison to the other two stations. Wind induced coastal mixing, and more importantly the excess nutrient supply from the nearby Lamas River throughout the year are the major factors controlling the phytoplankton production in the nearshore station. The observed rapid changes in surface salinity also depicts the river effect at this station.

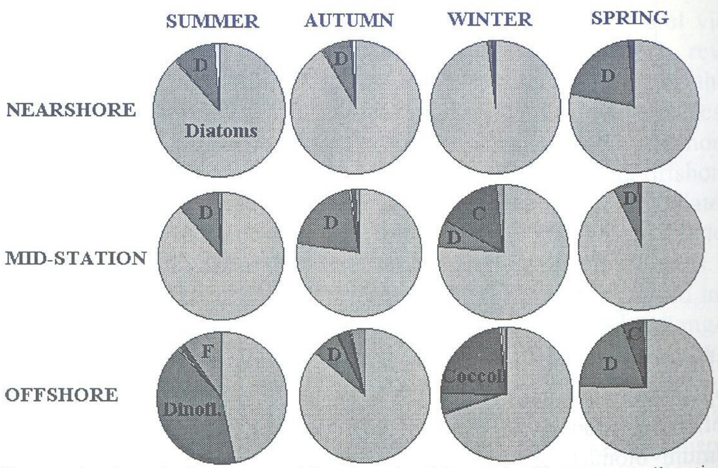

Fig. 2. Changes in phytoplankton composition (based on biomass) with season at all stations, (D = Dinoflagellates, C = Coccolithophorids, F = Flagellates).

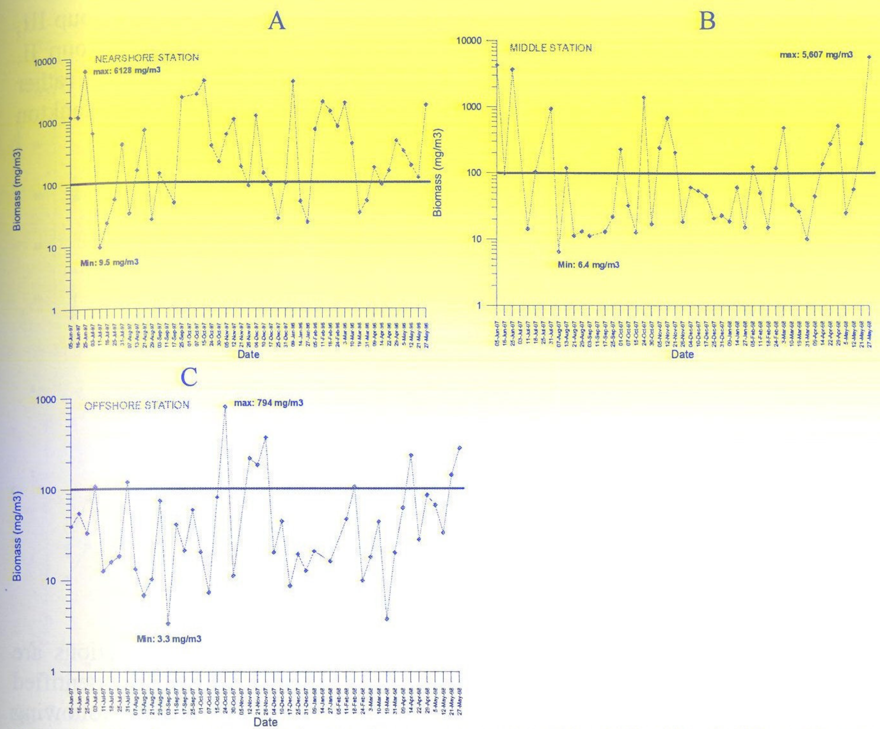

Fig. 3. Weekly changes in phytoplankton biomass at nearshore (a), middle (b) and offshore (c) stations.

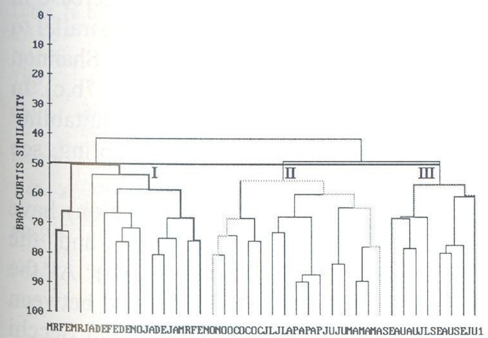

Fig. 4. Dendogram showing classification of the monthly phytoplankton populations with three major clusters distinguished at an arbitrary similarity level of 50 %.

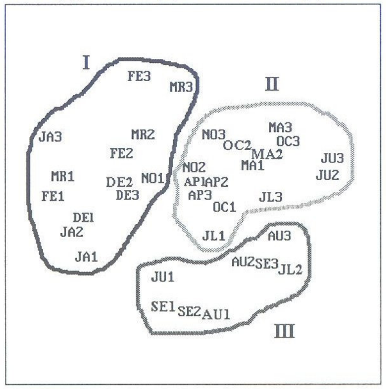

Fig. 5. Two-dimensional non-metric MDS configuration of monthly phytoplankton assembleges.

Figure 5 shows two-dimensional non-metric MDS plots of phytoplankton populations (based on monthly averages of cell abundances) with 3 distinct groups. The groups were separated at an arbitrary similarity level of 50% as illustrated in

Fig. 4. Group I represents the colder winter-early spring population and group III, the much warmer late summer-early autumn populations. The largest, group II, contains intermediate spring, summer and autumn populations. Temperature rather than salinity was found to be more effective in determining phytoplankton composition in the region (Fig. 6).

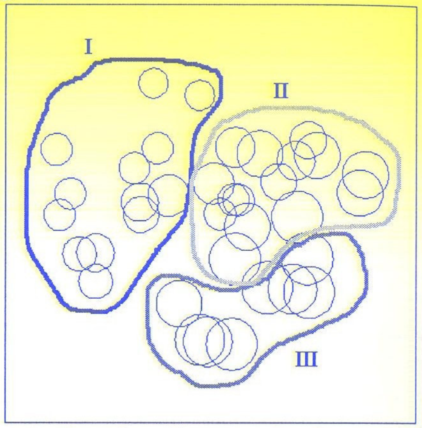

Fig. 6. MDS plots of superimposed values of monthly averaged surface temperatures.

Monthly changes in total number of species identified at three stations are shown in Fig. 7a. It is clearly illustrated that the number of species identified during late autumn - early winter period were highest compared to the following spring and summer periods. From May to September much more species were present at the nearshore station compared to the other two. A gradual decrease in number of species at all stations are also observed in the same period. In parallel to total number of species present, species richness (Margalef's Index d) and Shannon indices were found highest during late autumn- early winter periods (Fig. 7b,c). In times where few species dominated the community, the lowest equitability measures (Evenness Index J) are obtained (mainly during winter and spring, see Fig. 7d).

Highly significant correlations (based on Spearmans Rank Correlation) have been observed between the ambient physico-chemical parameters and the phytoplankton biomass and abundance at three stations (Tables 1a,b,c). At the nearshore station (Table 1a) highly significant relationships are observed between phytoplankton biomass and TSS (Total Suspended Sediment), Chl.-*a* and Secchi depth. Correlations are also observed between cell abundance and nutrients (nitrate-nitrogen and silicate). This is as well true for the middle station. However in the offshore station the only highly significant (r_s significant at $P_{.001}$) relationship is observed between phytoplankton biomass and salinity.

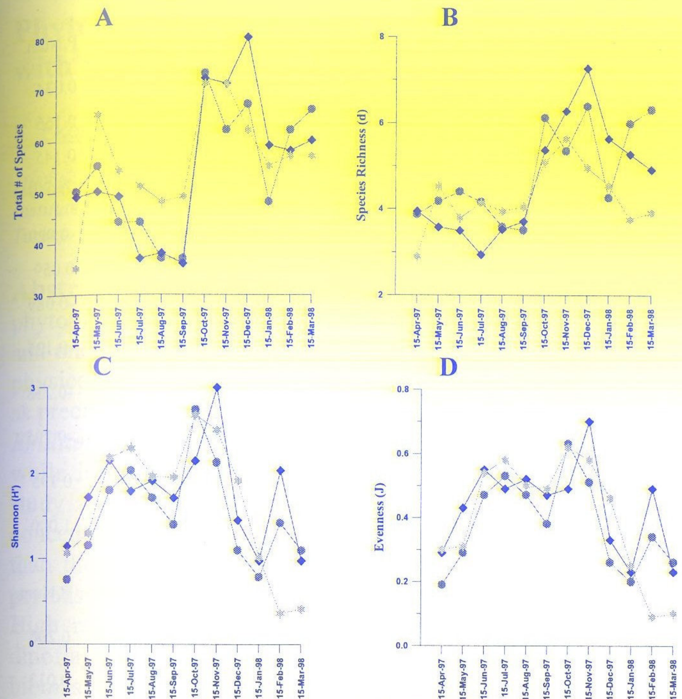

Fig. 7. Changes in total number of species (a), Species Richness (b), Shannon (c) and Evenness (d) indice measures throughout the year at nearhore (∗), middle (◆) and offshore station (●).

Table 1a,b,c. Relationships between ambient parameters and phytoplankton abundance and biomass.

CASE NAME	TSS	Chl-a	Phaeo.	T.Chl-a	PO_4P	NO_3N	Si	Secchi	Temp.	Salinity	P.Biom	P.Num.
TSS	1.000	0.361	-0.059	0.479	0.178	0.046	0.201	-0.498	0.104	-0.276	0.360	0.161
Chl-a	0.361 ****	1.000	-0.123	0.810	-0.005	0.061	0.282	-0.544	-0.339	-0.411	0.332	0.451
Phaeo.	-0.059	-0.123	1.000	-0.180	-0.157	-0.110	-0.042	0.138	-0.067	-0.016	0.008	-0.037
T.Chl-a	0.479 ****	0.810	-0.180	1.000	0.070	0.118	0.316	-0.643	-0.369	-0.497	0.442	0.431
PO_4P	0.178	-0.005	-0.157	0.070	1.000	0.124	0.172	0.018	-0.127	-0.202	-0.081	0.066
NO_3N	0.046	0.061	-0.110	0.118	0.124	1.000	0.383	-0.024	-0.218	0.028	-0.058	0.240
Si	*	0.282 **	-0.042	0.316	0.172	0.383	1.000	-0.185	-0.321	-0.310	-0.101	0.250
Secchi	-0.498 ****	****	0.138	-0.643 ****	0.018	-0.024	-0.185 *	1.000	0.183	0.325	-0.230	-0.258
Temp.	0.104	-0.339 ***	-0.067	-0.369 ****	-0.127	**	-0.321 ***	0.183 *	1.000	0.565	-0.162	-0.309
Salinity	-0.276	-0.411 ****	-0.016	-0.497 ****	-0.202	0.028	-0.310 ***	0.325 ***	****	1.000	-0.428	-0.270
P.Biom.	0.360 ****	0.332	0.008	0.442 ****	-0.081	-0.058	-0.101	-0.230 **	-0.162	-0.428 ****	1.000	0.324
P.Num.	0.161	0.451 ****	-0.037	0.431 ****	0.066	0.240	0.250 **	**	-0.309 ***	-0.270 **	0.324 ***	1.000

Table 1b.

CASE NAME	TSS	Chl-a	Phaeo.	T.Chl-a	PO_4P	NO_3N	Si	Secchi	Temp.	Salinity	P.Biom	P.Num.
TSS	1.000	0.039	0.132	0.230	-0.175	0.059	0.063	-0.254	0.173	-0.120	0.306	0.034
Chl-a	0.039	1.000	0.059	0.054	-0.015	-0.095	0.158	-0.032	-0.107	-0.009	-0.066	0.166
Phaeo.	0.132	0.059	1.000	-0.160	0.064	0.122	0.031	0.156	0.061	0.064	0.015	0.145
T.Chl-a	0.230 **	0.054	-0.160	1.000	0.001	0.002	0.099	-0.347	-0.020	-0.385	0.357	-0.049
PO_4P	-0.175	-0.015	0.064	0.001	1.000	0.140	0.125	-0.055	-0.121	0.059	0.047	-0.029
NO_3N	0.059	-0.095	0.122	0.002	0.140	1.000	0.259	0.077	0.219	0.086	-0.227	0.059
Si	0.063	0.158	0.031	0.099	0.125	0.259 **	1.000	-0.134	-0.156	-0.118	-0.080	-0.089
Secchi	-0.254 **	-0.032	0.156	-0.347 ***	-0.055	0.077	-0.134	1.000	0.270	0.565	-0.528	-0.125
Temp.	0.173	-0.107	0.061	-0.020	-0.121	0.219 **	-0.156	0.270 **	1.000	0.404	-0.138	-0.218
Salinity	-0.120	-0.009	0.064	-0.385 ****	0.059	0.086	-0.118	0.565 ****	0.404 ****	1.000	-0.617	-0.295
P.Biom.	0.306 ***	-0.066	0.015	0.357 ****	0.047	-0.227 **	-0.080	-0.528 ****	-0.138	-0.617 ****	1.000	0.195
P.Num.	0.034	0.166	0.145	-0.049	-0.029	0.059	-0.089	-0.125	-0.218 **	-0.295 ***	0.195 *	1.000

Table 1c.

CASE NAME	TSS	Chl-a	Phaeo.	T.Chl-a	PO_4P	NO_3N	Si	Secchi	Temp.	Salinity	P.Biom	P.Num.
TSS	1.000	0.097	0.191 *	0.018	-0.077	-0.143	0.042	-0.073	0.037	-0.155	0.207	0.206
Chl-a	0.097	1.000	0.069	-0.059	0.147	-0.065	0.028	0.109	-0.170	0.198	-0.098	0.013
Phaeo.	0.191 *	0.069	1.000	-0.458	0.217	0.071	0.352	0.024	-0.075	0.219	-0.024	-0.128
T.Chl-a	0.018	-0.059	-0.458 ****	1.000	-0.189	0.101	-0.260	-0.143	0.190	-0.193	-0.030	0.084
PO_4P	-0.077	0.147	0.217 **	-0.189 *	1.000	-0.086	0.109	0.134	-0.036	0.232	-0.094	-0.170
NO_3N	-0.143	-0.065	0.071	0.101	-0.086	1.000	0.162	0.070	0.152	0.085	-0.187	0.042
Si	0.042	0.028	0.352 ***	-0.260 **	0.109	0.162	1.000	0.081	-0.268	-0.154	-0.031	0.132
Secchi	-0.073	0.109	0.024	-0.143	0.134	0.070	0.081	1.000	0.212	0.327	-0.190	-0.001
Temp.	0.037	-0.170	-0.075	0.190 *	-0.036	0.152	-0.268 **	0.212 *	1.000	0.434	-0.259	-0.207
Salinity	-0.155	0.198 *	0.219 **	-0.193 *	0.232 **	0.085	-0.154	0.327 ***	0.434 ****	1.000	-0.405	-0.199
P.Biom.	0.207 *	-0.098	-0.024	-0.030	-0.094	-0.187 *	-0.031	-0.190 *	-0.259 **	-0.405 ****	1.000	0.245
P.Num.	0.206 *	0.013	-0.128	0.084	-0.170	0.042	0.132	-0.001	-0.207 *	-0.199 *	0.245 **	1.000

n = 82

* = Significant at $P_{.10}$ ** = Significant at $P_{.05}$

*** = Significant at $P_{.01}$ **** = Significant at $P_{.001}$

References

Uysal, Z., 2000. A time series study to determine anthropogenic influences on ecological cycles and long-term changes in the Northern Levantine Basin. Final Report. MAP-Med Poll Phase III. Supported by TUBİTAK & UNESCO - IOC. IMS-METU, Erdemli-Turkey. 48 p.